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Hama

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[54] **ROTARY DEVELOPMENT UNIT WHICH SUPPLIES FRESH TONER BACK TO A TONER SUPPLY CONTAINER**

[75] Inventor: **Junichi Hama**, Ebina, Japan

[73] Assignee: **Fuji Xerox Co., Ltd.**, Tokyo, Japan

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[30] **Foreign Application Priority Data**

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[51] **Int. Cl.**^{6} **G03G 15/01**

[52] **U.S. Cl.** **399/227**

[58] **Field of Search** 399/223, 226, 399/227, 228

[56] **References Cited**

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Primary Examiner—S. Lee

Attorney, Agent, or Firm—Oliff & Berridge, PLC

[57] **ABSTRACT**

A rotary development unit includes a support frame having a plurality of developers arranged in a radial pattern and places any one of the developers in a development position opposite to a photosensitive drum by rotation while retaining the developers; a plurality of toner supply containers attached to the support frame so as to become adjacent to the respective developers; toner supply channels which are disposed substantially in parallel with a rotary shaft of the support frame and connect the respective developers to the adjacent toner supply containers; and supply augers which convey fresh toner to the developers from the toner supply containers within the toner supply channels according to a given number of rotations. In the rotary development unit, when the supply auger is suspended and the support frame is rotated, the fresh toner filled in the toner supply channel is conveyed to the toner supply container from the developer.

4 Claims, 7 Drawing Sheets

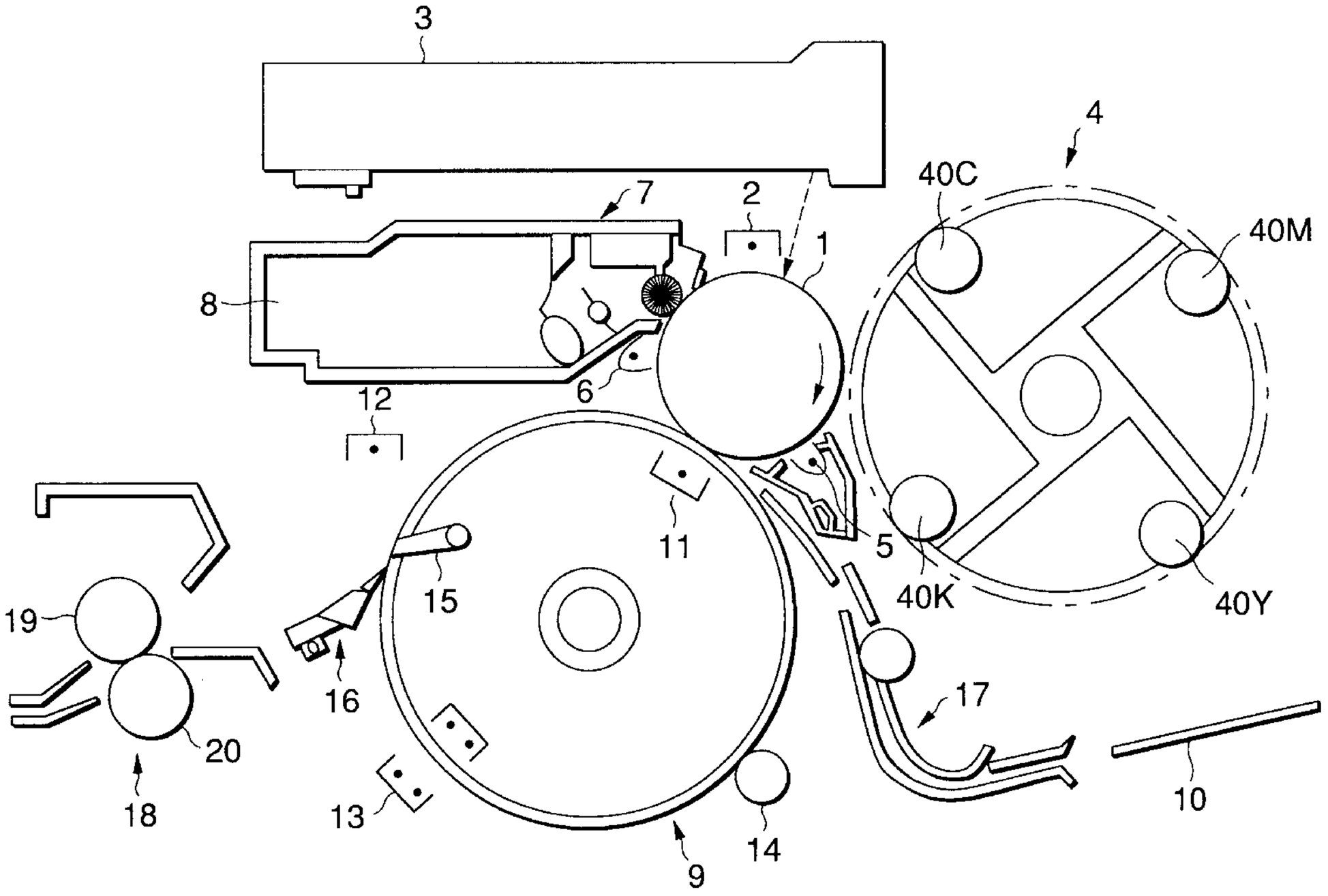
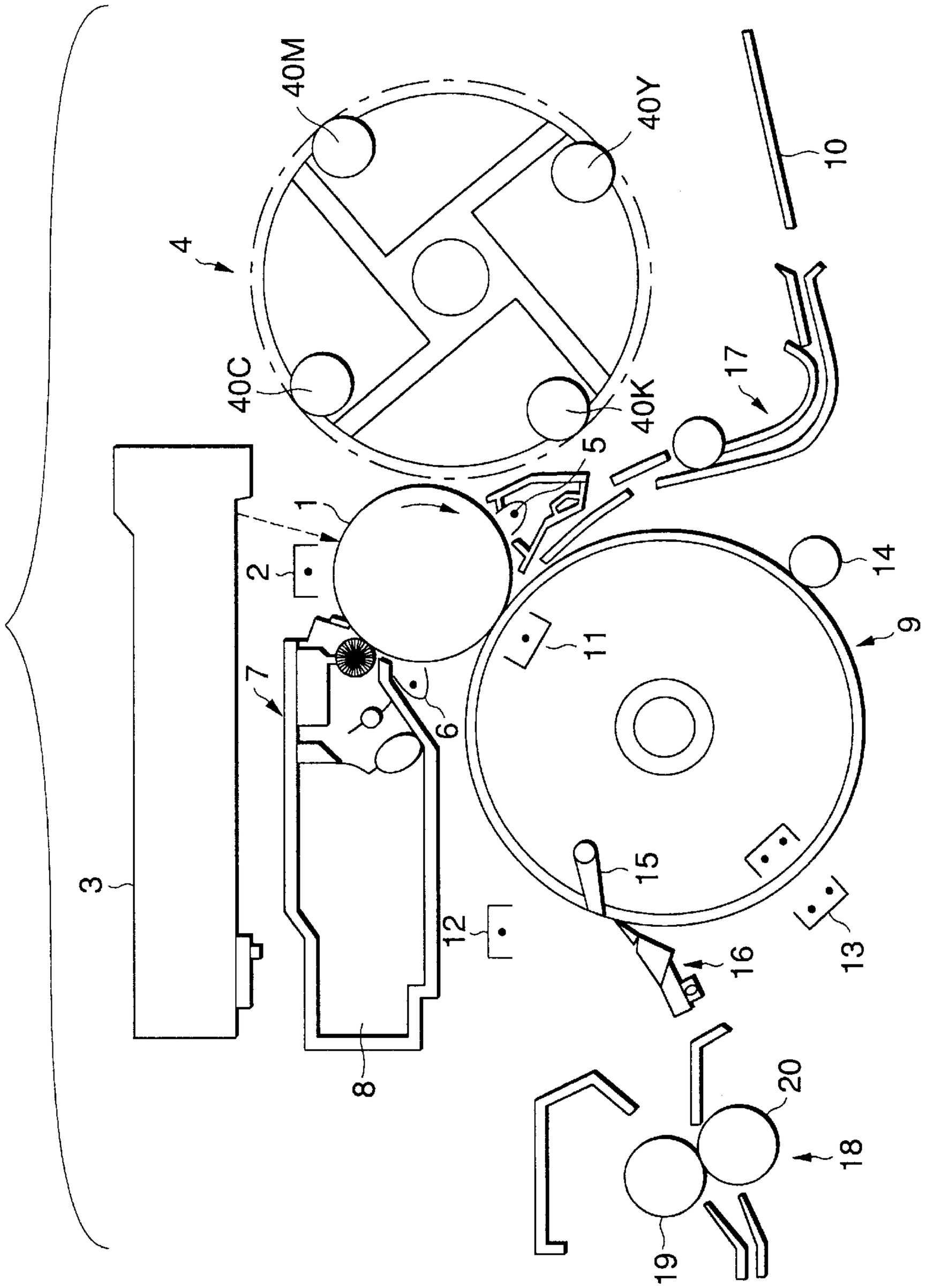


FIG. 1



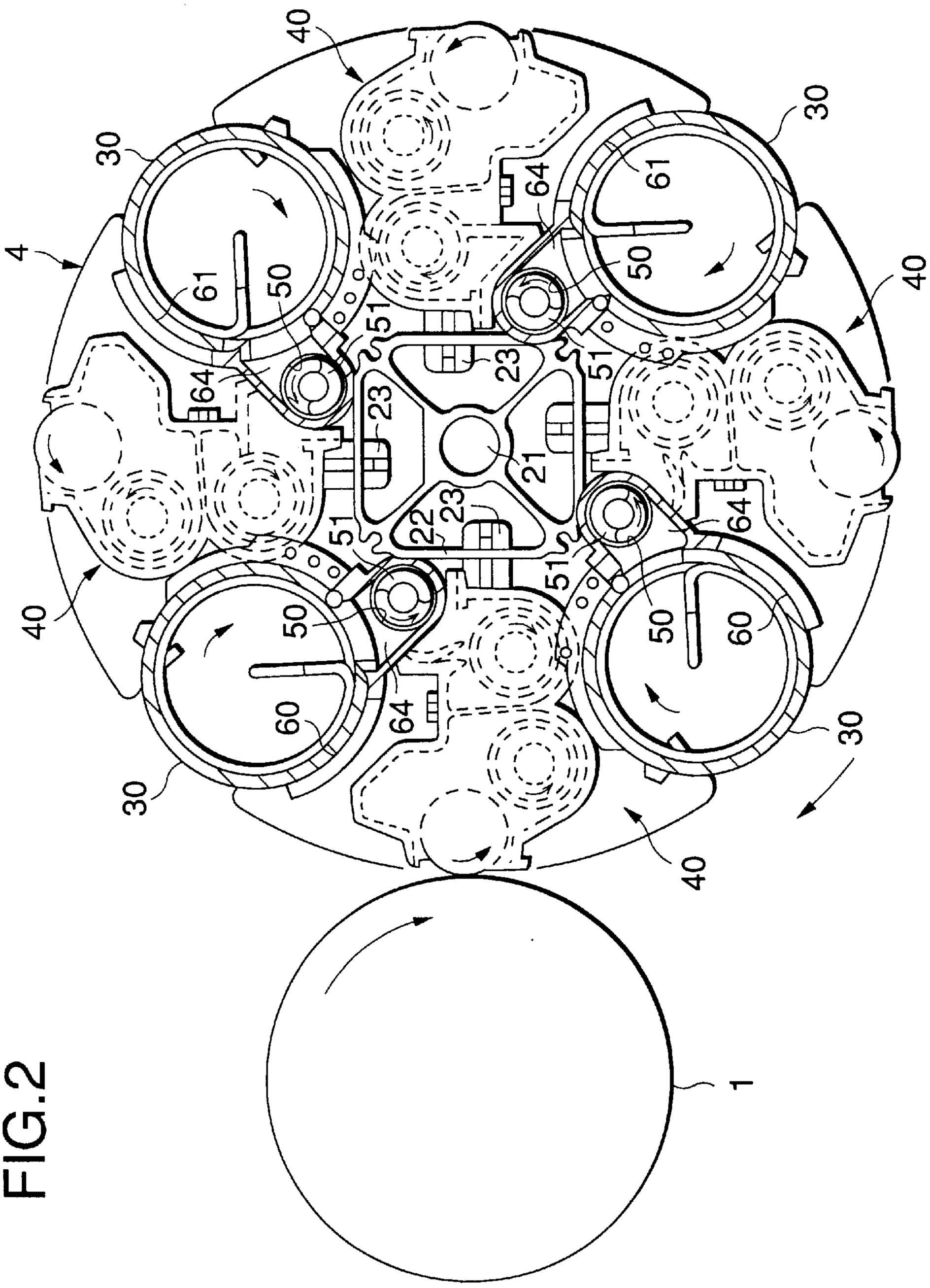


FIG.2

FIG.3

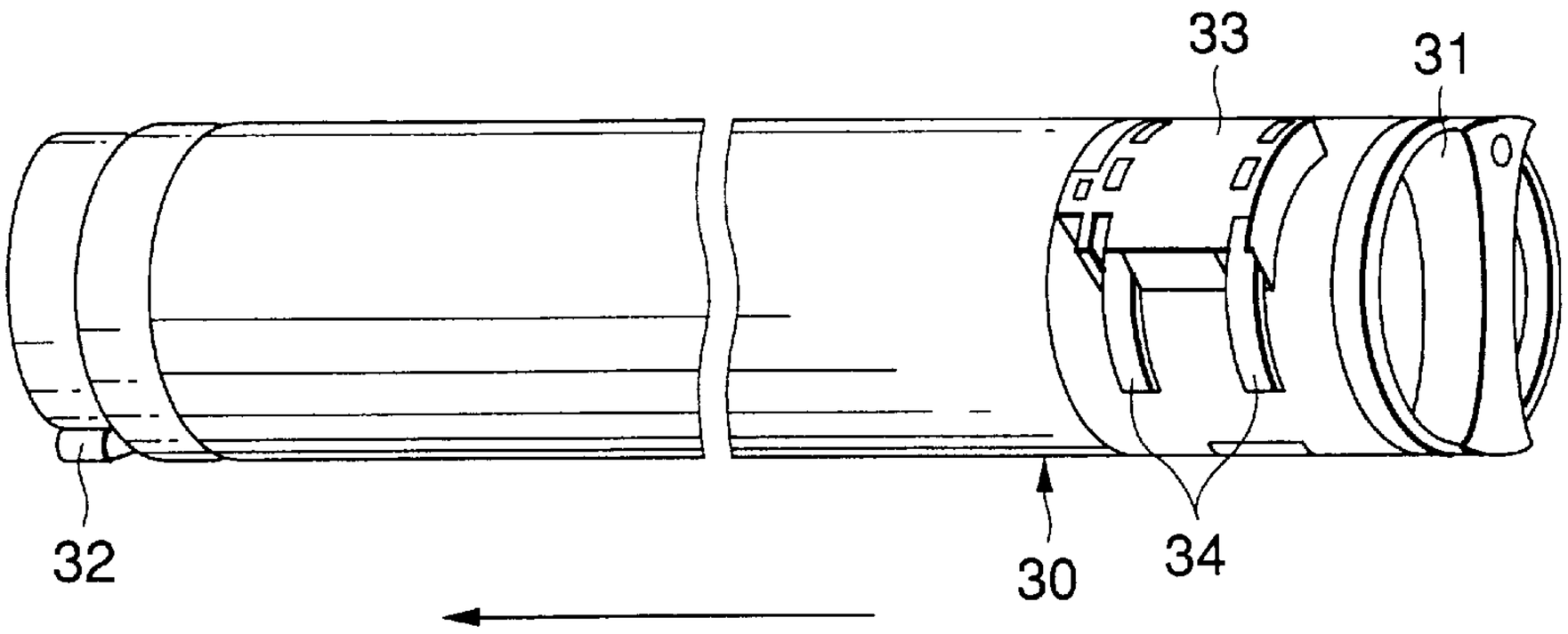
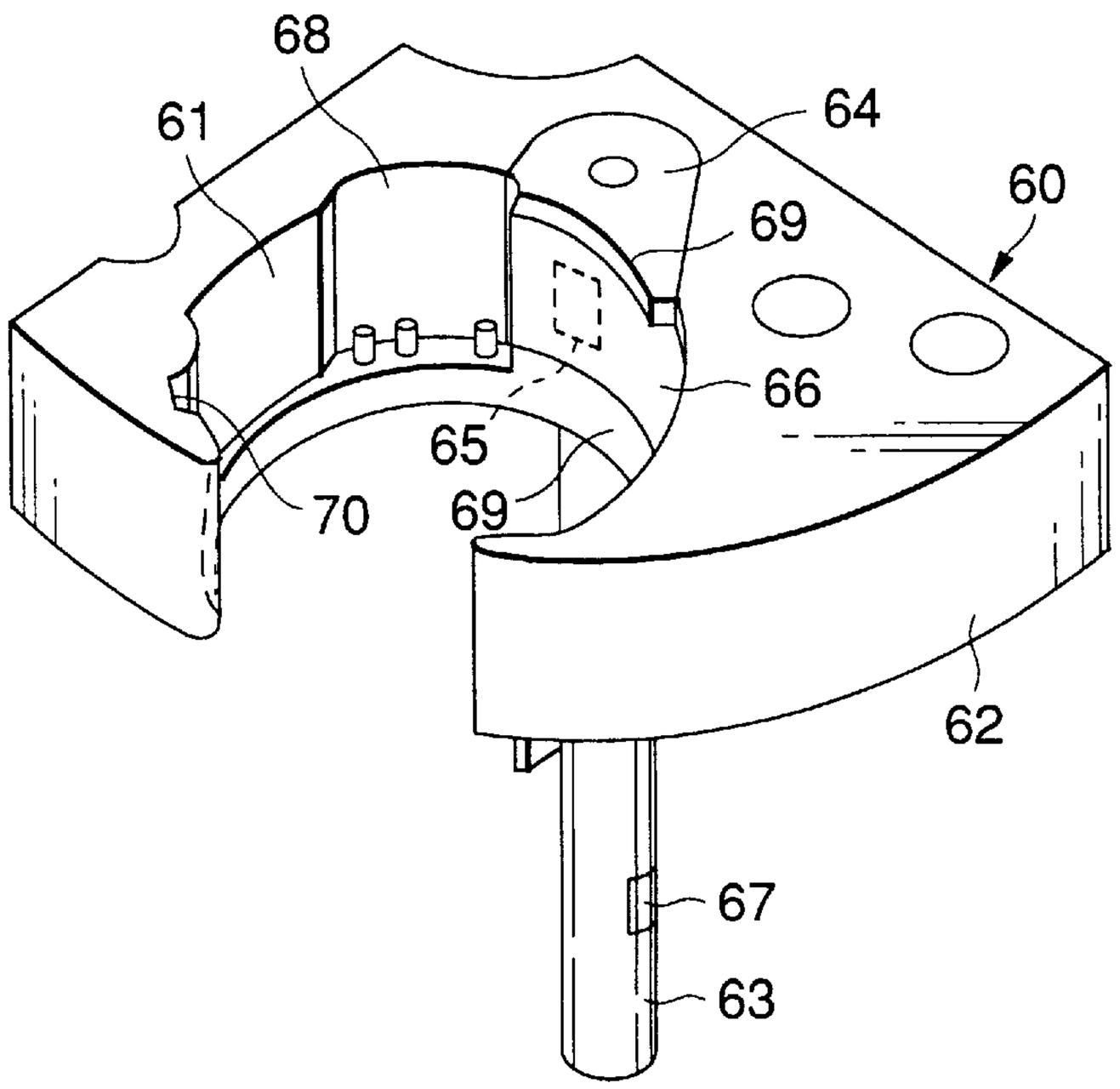

33
31
32
30
34
DIRECTION OF INSERTION

FIG.4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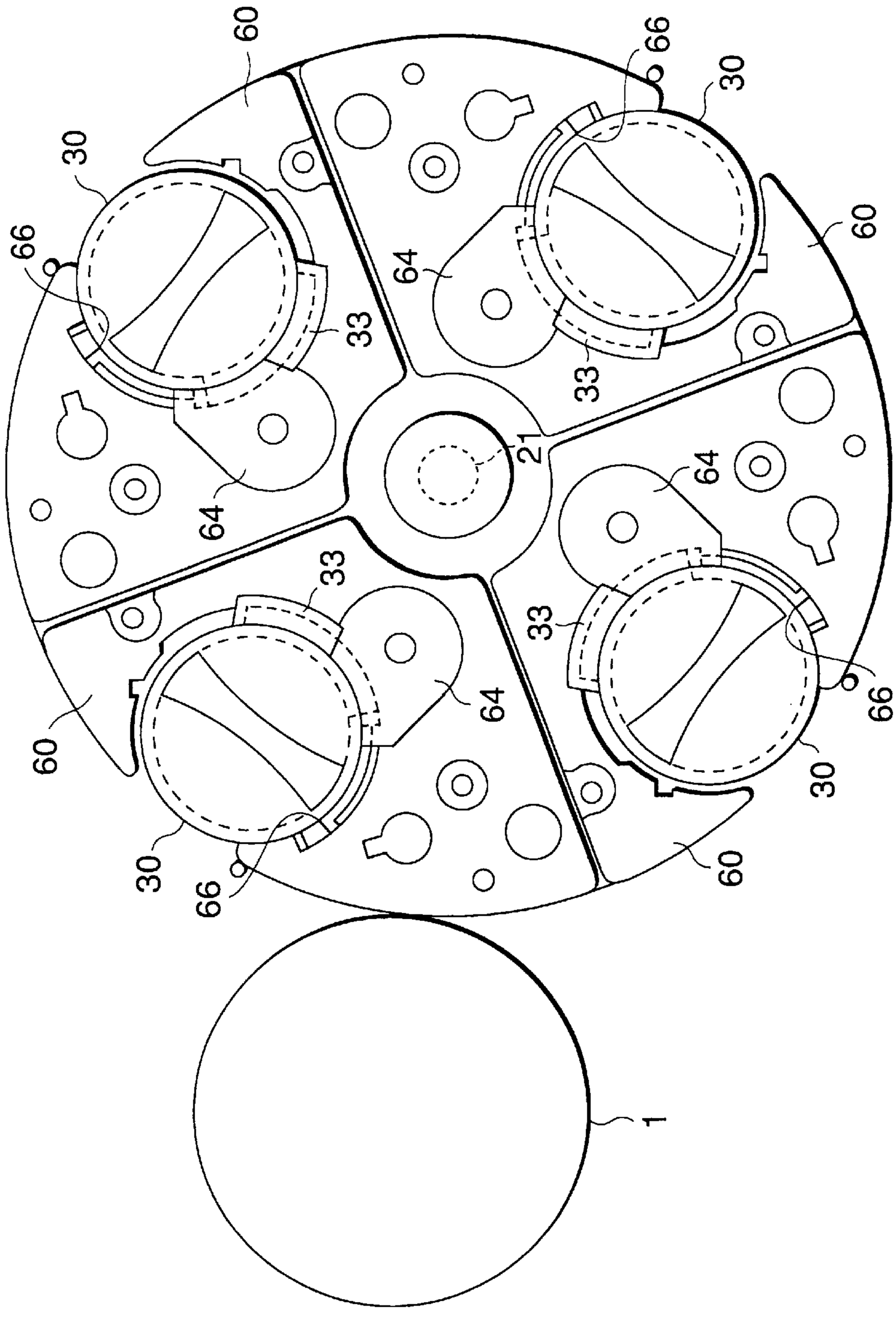


FIG.5

FIG.6

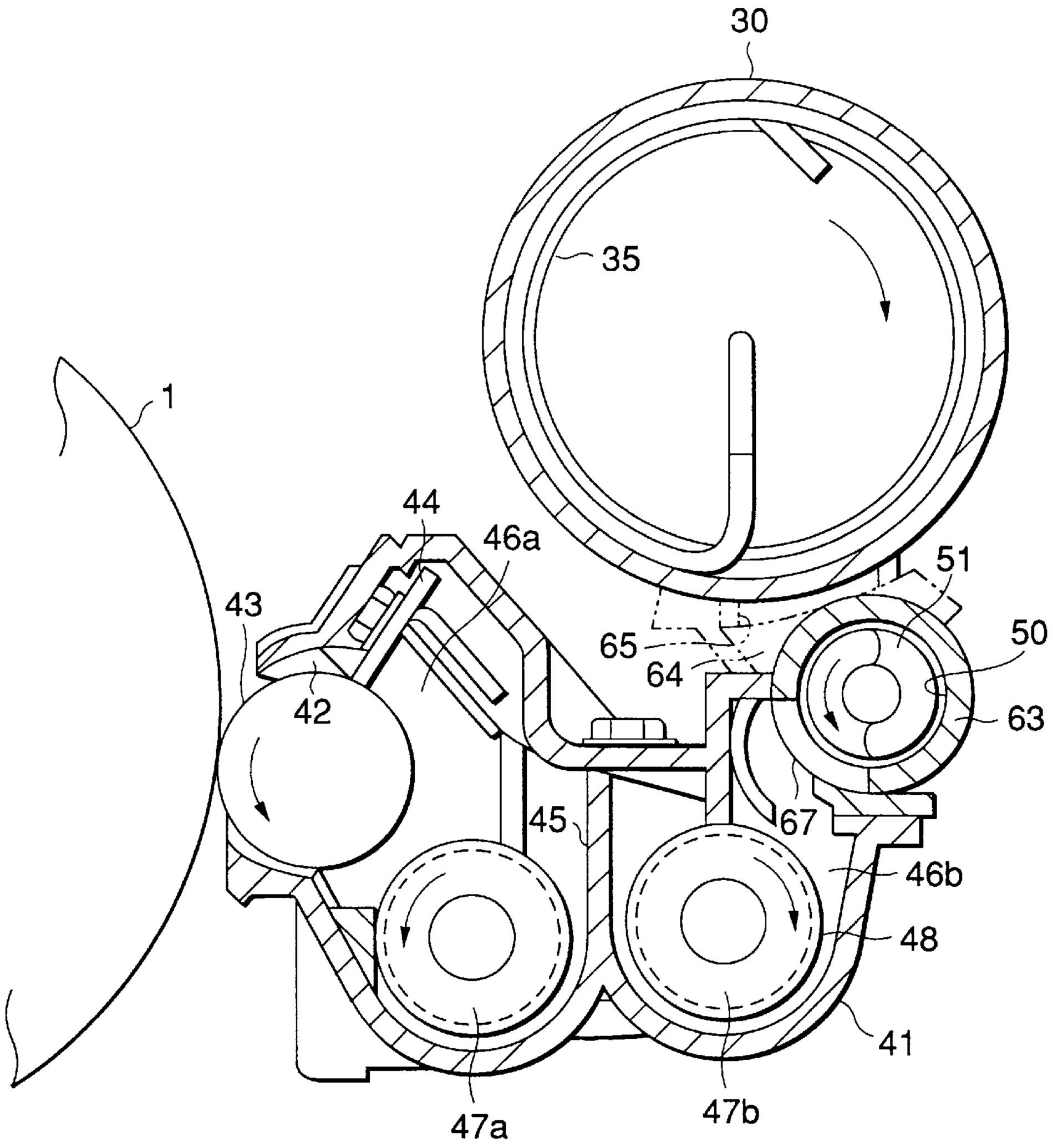
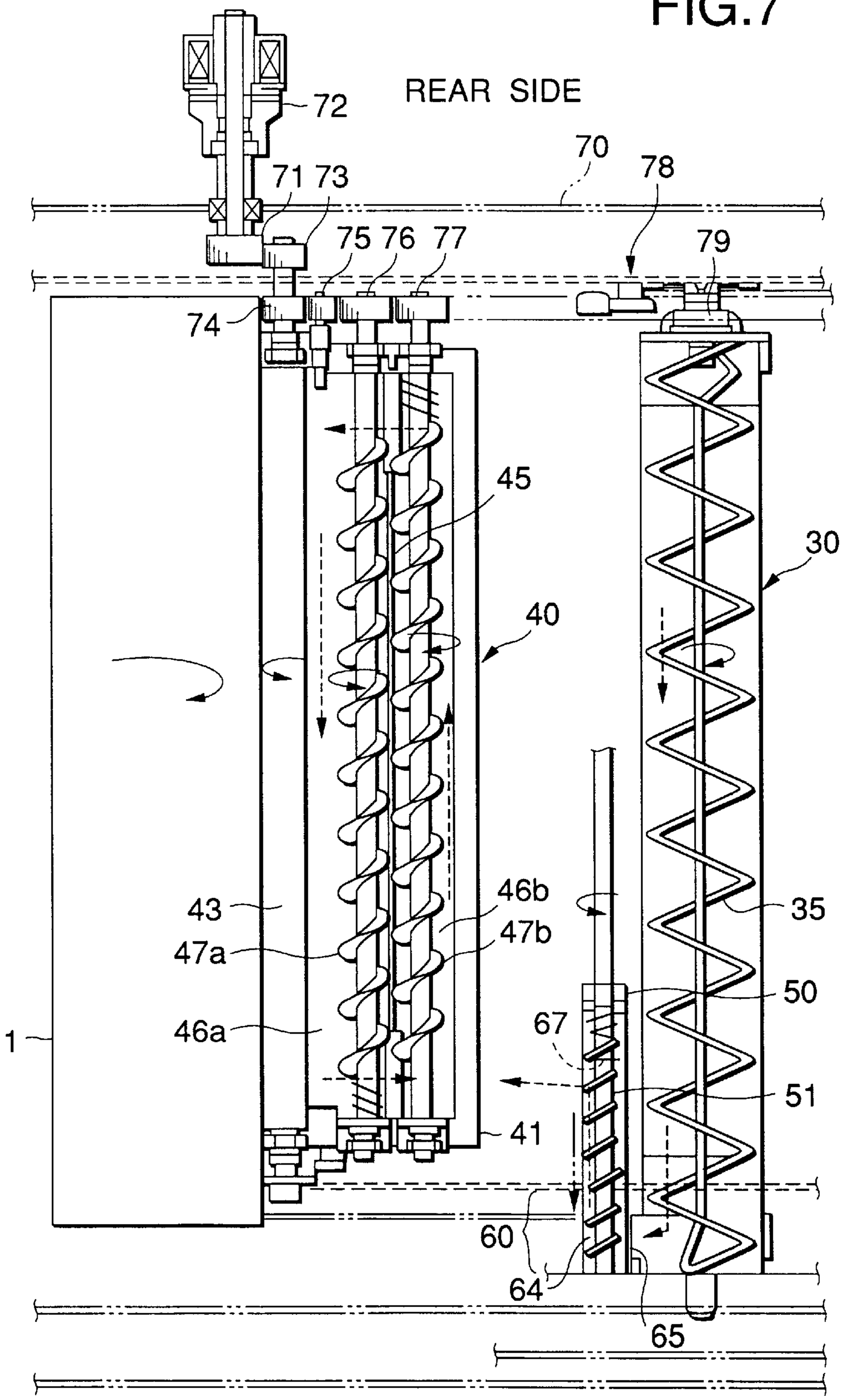


FIG.7


REAR SIDE
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74
45
40
30
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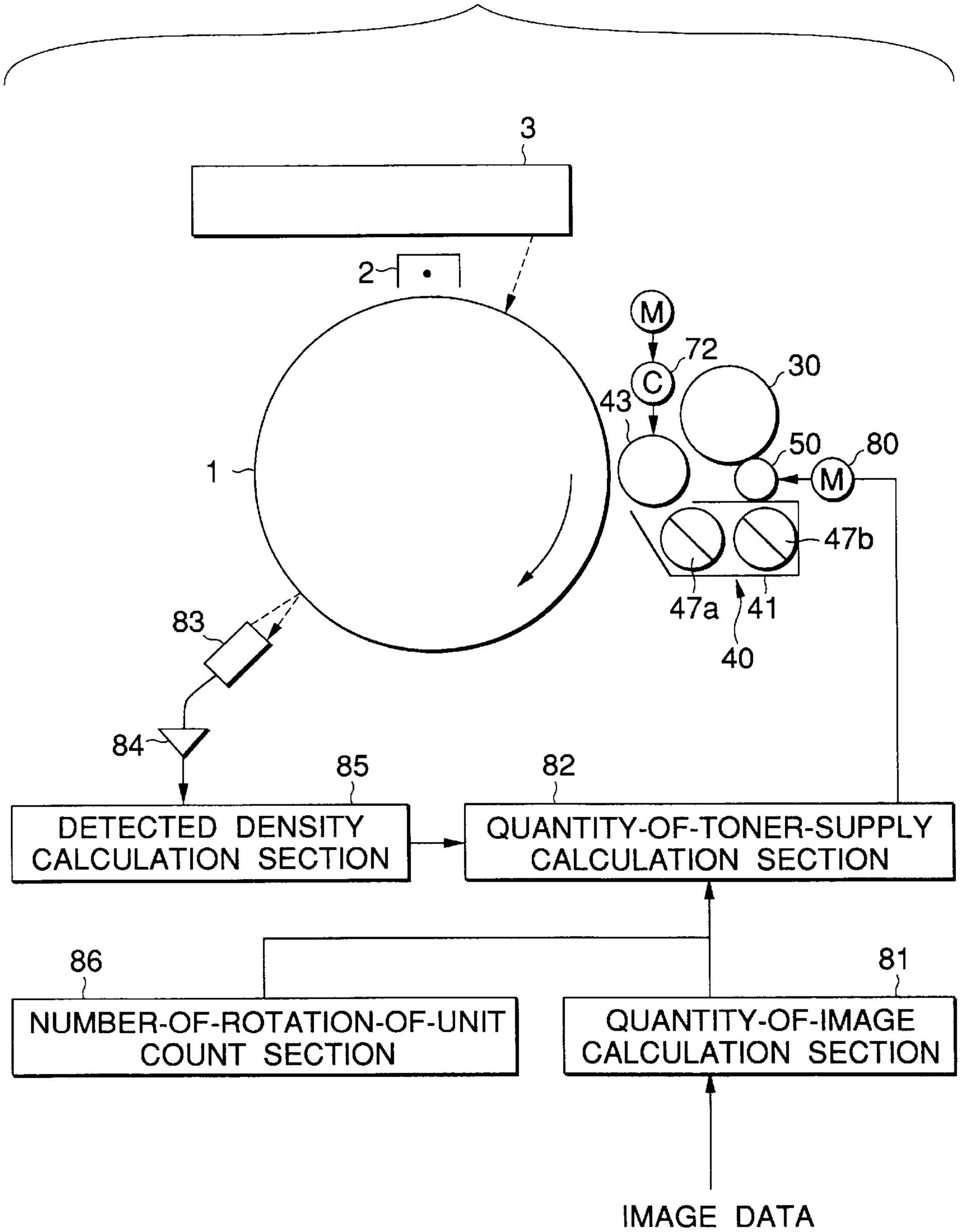
46a
50
67
1
51
41
60
64
65
FRONT SIDE

FIG.8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M
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C
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DETECTED DENSITY CALCULATION SECTION
QUANTITY-OF-TONER-SUPPLY CALCULATION SECTION
86
81
NUMBER-OF-ROTATION-OF-UNIT COUNT SECTION
QUANTITY-OF-IMAGE CALCULATION SECTION
IMAGE DATA

ROTARY DEVELOPMENT UNIT WHICH SUPPLIES FRESH TONER BACK TO A TONER SUPPLY CONTAINER

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a development unit, for use in an electrophotographic copier or a printer, which includes a plurality of developers containing toner of different colors and visualizes an electrostatic latent image formed on an image carrier, such as a photosensitive drum, by means of a developer arbitrarily selected from the developers. More particularly, the present invention relates to an improvement in a so-called rotary development unit which exchanges a developer with another one in a position opposite to the image carrier while rotating the developer around a rotary shaft.

2. Description of the Related Art

An existing color image forming apparatus which employs an electrophotographic method includes a well-known color image forming apparatus which employs a so-called multiple transfer method. In this apparatus, yellow, cyan, magenta, and black toner images are sequentially transferred to a recording sheet, and these toner images are superimposed on each other to thereby form a full color image.

In the multiple transfer method, it is necessary to form a toner image of each color on an image carrier, such as a photosensitive drum, one after another. For this reason, a plurality of developers, each of which contains toner of each color, are disposed in a position where any one color developer is selectively placed opposite the image carrier. The other developers must be held in a receded position separated from the image carrier.

To this end, an existing color image forming apparatus employs a so-called rotary development unit (A-Color manufactured by Fuji Xerox Co., Ltd.) as means for selectively setting developers of four colors with in a development position. In this rotary development unit, a plurality of developers are positioned at equal intervals around a cylindrical rotary member (hereinafter referred to as a developer exchanger). As a result of revolution of the developer exchanger, an arbitrary developer is set in the development position, and the other developers are held in a receded position relative to the position where the developer is in close proximity to the image carrier.

If color toner, such as yellow toner, cyan toner, or magenta toner, is mixed with magnetic powder, the color developing characteristics of the color toner are deteriorated. For this reason, the color toner is usually non-magnetic toner, and each developer of the aforementioned color image forming apparatus develops an electrostatic latent image formed on the image carrier by means of a two-component development method; i.e., a two-component developing agent including a mixture of non-magnetic toner and magnetic carriers.

According to the development method that employs the two-component developing agent, only the toner of the mixture of toner and carriers contained in the developer is consumed through development of an electrostatic latent image. Therefore, each of the developers retained by the developer exchanger should be replenished with new toner (hereinafter referred to as fresh toner). In order to constantly maintain a desired development density of an electrostatic latent image, the quantity of fresh toner to be supplied to the developer must be strictly controlled.

The applicant of the present patent application has already put forward a rotary development unit which satisfies the foregoing demand. The rotary development unit is arranged so as to permit insertion or removal of a toner supply container storing fresh toner into or from the developer exchanger in such a way as to be in proximity to each color developer. The toner supply container attached to the developer exchanger is connected to the color developer through a toner supply channel disposed in parallel with the rotary shaft of the development exchanger. A conveyor screw comprising a rotary shaft around which a helical vane is wrapped (hereinafter referred to as an auger) is provided so as to pass through the toner supply channel. The fresh toner unloaded to the toner supply channel from the toner supply container is fed to the developer by rotation of the auger.

In the rotary development unit having the foregoing structure, the quantity of fresh toner corresponding to the number of rotations of the auger disposed in the toner supply channel is fed to the developer. Accordingly, if toner consumption is predicted from the image data read by the image forming apparatus, and the number of rotations of the auger is adjusted so as to correspond to the predicted toner consumption, the development density of an electrostatic latent image can be constantly maintained.

In the previously-described rotary development unit, the developers, the toner supply containers, and the toner supply channels revolve around the rotary shaft of the developer exchanger every time the developer exchanger is rotated for the purpose of exchanging the developer to be placed in the development position. Even in a state in which the augers housed in the toner supply channels are stopped, fresh toner moves along the helical vane of the auger and is naturally conveyed through the toner supply channel.

For this reason, in a case where the developer exchanger rotates in one direction, the fresh toner held in the toner supply channel is conveyed through the inside of the toner supply channel toward the developer or the toner supply container depending on the direction in which the helical vane of the auger is wrapped. In the former case, the developer is unintentionally replenished with fresh toner, thereby resulting in an excess quantity of toner being stored in the developer. In contrast, in the latter case, the fresh toner recedes to the toner supply container from the toner supply channel. Accordingly, if an attempt is made to replenish the developer with the fresh toner by effecting a given number of rotations of the auger, the quantity of fresh toner corresponding to the number of rotations of the auger cannot be supplied to the developer, thereby resulting in toner deficiency in the developer.

Such a problem is particularly likely to arise in a developer other than a black developer after a copy job has been repeatedly executed several times in a black and white mode. In order to prevent the surface of the latent image carrier from being soiled by toner, a home position at which any developer is spaced away from a latent image carrier is ensured in the color image forming apparatus that uses the rotary development unit. In a copy wait state, the developer exchanger is usually set in its home position. If there are successive copy jobs in a black and white mode, the black developer is carried from the home position to the development position where it faces the latent image carrier at the beginning of each job. Further, after the completion of the job, the black developer is returned to the home position. As a result, the developer exchanger is rotated for each job, and the other color developers are not used at all during the course of the copy jobs. If the copy jobs are repeated several times in a black and white mode, the fresh toner held in the

toner supply channel of each of the other color developers; i.e., the yellow developer, the cyan developer, and the magenta developer, is unintentionally carried, thereby resulting in the foregoing problems being more noticeable.

In the case where an excess arises in the quantity of fresh toner to be supplied to the developer, there is no alternative way but to wait for consumption of the toner contained in the developer through development over time until the development density of an electrostatic latent image is adjusted. In contrast, in the case where there is a shortage of fresh toner in the developer, it is sufficient to rotate the auger housed in the toner supply channel to the number of rotations corresponding to the insufficient amount of the fresh toner.

SUMMARY OF THE INVENTION

The present invention has been contrived in view of the foregoing drawbacks in the art, and the object of the present invention is to provide a rotary development unit which exchanges a developer to be set opposite to an image carrier, as required, by rotation of a developer carrier retaining a plurality of developers in a circumferential position around the carrier; which prevents an excess quantity of fresh toner being supplied to the developer which would otherwise be caused by rotation of the developer exchanger; and which is capable of developing an electrostatic latent image formed on an image carrier in stable density.

Another object of the present invention is to prevent an insufficient amount of fresh toner being supplied to the developer which would otherwise be caused by rotation of the developer exchanger, and which is capable of developing an electrostatic latent image formed on an image carrier in a stable density.

To accomplish the foregoing problems, a rotary development unit including a plurality of developers for visualizing an electrostatic latent image formed on a latent image carrier with toner through development; a developer exchanger which rotates while retaining the developers in a circumferential position around the developer exchanger and places any one of the developers in a development position opposite to the latent image carrier; a plurality of toner supply containers which store fresh toner to be supplied to the respective developers and are attached to the developer exchanger adjacent to the respective developers; toner supply channels which are provided in substantially parallel with the rotary shaft of the developer exchanger and connect the developers to their adjacent toner supply containers; and toner conveyor device for conveying the quantity of fresh toner corresponding to a given number of rotations of the toner conveyor device, from the toner supply container to the developer through the toner supply channel, wherein the fresh toner in the toner supply channel is conveyed to the toner supply container from the developer when the toner conveyor device is suspended and the developer exchanger is rotated.

With the foregoing technological means, if the developer exchanger is rotated while the toner conveyor device for conveying fresh toner from the toner supply container to the developer is suspended, the fresh toner held in the toner supply channel is conveyed to the toner supply container from the developer. As a result, the fresh toner is unintentionally prevented from being supplied to the developer from the toner supply channel during rotation of the developer exchanger, thereby preventing an excess quantity of toner from being stored in the developer.

Further, with the foregoing technological means, the fresh toner is withdrawn to the toner supply container through the toner supply channel by rotation of the developer exchanger. As a result, the toner supply channel becomes empty, and hence even if the toner conveyor device is rotated after the developer exchanger has been rotated several times, the quantity of fresh toner corresponding to the number of rotations of the toner conveyor device cannot immediately be supplied to the developer. Conversely, fears are entertained as to a shortage of toner in the developer.

To eliminate these fears, when the rotary developing unit of the present invention is practiced, it is desirable to add to following features to the developing unit; namely, number-of-rotation count section for counting the number of rotations achieved by the developer exchanger until the developer receded from the development position is reset to the same position; and quantity-of-supply correction section which determines, from the number of counts counted by the number-of-rotation count section, a corrected value of a time period over which the toner conveyor device is rotatively driven (hereinafter simply referred to as toner-conveyor drive time); and which increases the time period only by the corrected value.

If the rotary development unit, according to the present invention, is provided with the foregoing features, the number-of-rotation count section counts the number of rotations achieved by the developer exchanger. As a result, from the count value, it is possible to ascertain the extent to which the fresh toner has receded toward the toner supply container through the toner supply channel. If the toner-conveyor drive time is corrected and increased by means of the quantity-of-supply correction section on the basis of the count value, a shortage of fresh toner in the developer can be eliminated.

Even when the developer exchanger is in rotation, the fresh toner is conveyed to the developer through the toner supply channel at the time of rotation of the toner conveyor device, and the toner supply channel is filled with the fresh toner. Accordingly, if the toner conveyor device is subsequently rotated, the quantity of fresh toner corresponding to the number of rotations of the toner conveyor device is immediately supplied to the developer. For this reason, it is sufficient to count the number of rotations of the developer exchanger with the number-of-rotation count section only when the toner conveyor device is suspended.

Even if the developer exchanger makes tens of revolutions, the maximum distance over which the fresh toner is conveyed toward the toner supply container through revolution is equal to the length of the toner supply channel. There is no need to correct the toner-conveyor drive time in excess of the length of the toner supply channel. Accordingly, an upper limit value corresponding to the length of the toner supply channel should preferably be set as a corrected value for the toner-conveyor drive time.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** a schematic view showing the configuration of one example of a color copier to which a rotary development unit according to the present invention is applied;

FIG. **2** is a cross-sectional front view showing one embodiment of the rotary development unit according to the present invention;

FIG. **3** is a perspective view showing a toner supply container according to the embodiment;

FIG. **4** is a perspective view showing a panel member according to the present embodiment;

FIG. **5** is a front view showing the rotary development unit according to the present embodiment;

FIG. **6** is a cross-sectional view showing only a developer carried to a development position from the rotary development unit according to the present embodiment;

FIG. **7** is an exploded view showing the positional relationship between a developer, a toner supply container, and a toner supply channel according to the present embodiment; and

FIG. **8** is a block diagram showing a control system of a toner supply motor according to the present embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

By reference to the accompanying drawings, a rotary development unit according to the present invention will be described in detail.

FIG. **1** shows one example of a color copier equipped with the rotary development unit according to the present invention.

In the drawings, reference numeral **1** designates a photosensitive drum (an image carrier); **2** designates an electrostatic charging corotron for previously charging the surface of the photosensitive drum **1**; **3** designates a laser beam scanner used for writing an electrostatic latent image on the photosensitive drum **1** charged by the electrostatic charging corotron **2**; **4** designates a rotary development unit which rotatably retains four developers **40**K, **40**Y, **40**M, and **40**C for respectively receiving a black (K) toner image, a yellow (Y) toner image, a magenta (M) toner image, and a cyan (C) toner image and selects a developer in a switchable manner, as required; **5** designates a prior-to-transfer charge-removal corotron; **6** designates a prior-to-cleaning corotron; **7** designates a cleaner for removing residual toner from the photosensitive drum **1**; and **8** designates a recovery tank which is integrally formed with the cleaner **7** and collects wasted toner.

Reference numeral **9** designates a transfer drum around which a recording sheet **10** is wrapped, and a toner image of each color is transferred to the recording sheet **10** from the photosensitive drum **1**, whereby one color toner image is superimposed on another color toner image on the recording sheet **10**. A dielectric film made of, such as polyvinylidene fluoride, is stretched across a drum frame. The recording sheet **10** is electrostatically attached to the dielectric film.

The transfer drum **9** is provided with a transfer corotron **11** for transferring a toner image from the photosensitive drum **1** to the recording sheet **10**; a charge removal corotron **12** for removing electric charges from the recording sheet **10** after completion of transfer of the final color toner image onto the recording sheet **10**; a charge removal corotron **13** for removing electric charges from the dielectric film after the removal of the recording sheet **10**; a cleaning brush **14** for wiping off paper dust, or the like, adhered to the dielectric film; an inner press roller **15** for pressing the dielectric film from the inside of the transfer drum **9** when the recording sheet **10** is removed; and a release claw **16** for exfoliating the recording sheet **10** from the transfer drum **9**.

Reference numeral **17** designates a sheet supply system for guiding the recording sheet **10** supplied from a sheet supply cassette (not shown) to the transfer drum **9**. The recording sheet **10** is directly fed to a nip position where the photosensitive drum **1** comes into contact with the transfer drum **9**. More specifically, the transfer corotron **11** also plays a roll in attaching the recording sheet **10** to the transfer drum **9**. When the toner image on the photosensitive drum **1** is transferred to the recording sheet **10**, the recording sheet **10** is simultaneously attached to the transfer drum **9**.

Reference numeral **18** designates a fixing unit which fixes an unfixed toner image on the recording sheet **10** by enabling insertion of the recording sheet **10** which has finished undergoing the image transfer process. The fixing unit **18** is made up of a heating roll **19** having a built-in heater and a press roller **20** pressed against the heat roll **19**.

In the color copier according to the present embodiment having the foregoing structure, the photosensitive drum **1** is exposed to light through use of the laser beam scanner **3** on the basis of the image data concerning an original read by an original reading section (not shown), whereby a black (K) electrostatic latent image is written on the photosensitive drum **1**. In contrast, the black developer **40**K of the rotary development unit **4** is set in a position opposite to the photosensitive drum **1**. The electrostatic latent image is developed by means of the black developer **40**K after a slight delay with reference to the timing at which the image is written. The thus-formed black (K) toner image is transferred, at predetermined timing, to the recording sheet **10** supplied from the sheet supply system **17**. In association with the transfer of the toner image to the recording sheet **10**, the recording sheet **10** is attached to the transfer drum **9**. After that, the transfer drum **9** revolves while retaining the recording sheet **10**. After the black developer **40**K has finished developing the toner image, the developer is exchanged with another developer before the transfer drum **9** finishes making one rotation. Specifically, the yellow developer **40**Y is set to the position opposite to the photosensitive drum **1** by effecting 90ûiturn o development unit.

From then on, the foregoing operations are repeated every one turn of the transfer drum **9**. Every time the transfer drum **9** rotates, the yellow (Y) toner image, the magenta (M) toner image, or the cyan (C) toner image is transferred from the photosensitive drum **1** to the recording sheet **10** retained by the transfer drum **9**. As a result, toner images having four colors are superimposed one on another on the recording sheet **10**. After the transfer of the cyan (C) toner image to the recording sheet **10** has been completed, the recording sheet **10** is exfoliated from the transfer drum **9**. The thus-exfoliated recording sheet **10** is discharged to a discharge tray (not shown) by way of a fixing unit **18**.

The structure of the rotary development unit **4** will be described in detail.

As is evident from the cross-sectional view shown in FIG. **2**, the rotary development unit **4** includes a rotary shaft **21** provided at the center of the rotary development unit and a support frame **22** fixed on the rotary shaft **21**. The aforementioned four color developers **40** are fixed to the support frame **22** in a radial pattern through use of mount pins **23**. A developer exchanger motor (not shown) is connected to the rotary shaft **21** via a clutch. The support frame **22** is rotated by driving the developer exchanger motor, thereby enabling a desired developer **40** to be set in the development position opposite to the photosensitive drum **1**. Accordingly, the rotary shaft **21** and the support frame **22** correspond to the developer exchanger according to the present invention.

In the rotary development unit **4**, toner supply containers **30** are provided so as to be adjacent to the respective developers **40**. The fresh toner stored in each of the toner supply containers **30** is supplied to each of the developers **40** via a toner supply channel **50** disposed in parallel with the rotary shaft **21**, as required. The toner supply container **30** is cylindrically formed and can be removably inserted into a container inlet port **61** formed in a panel member **60**, which will be described later, from the front side of the rotary development unit **4** (i.e., in the fore direction at right angles to a drawing sheet of FIG. **2**).

FIG. **3** shows a toner supply container **30**. A knob **31** protrudes from the proximate end face of the toner supply container **30** in the direction designated by arrow in which the toner supply container **30** is inserted. A protuberance **32** for indexing purposes is formed on the circumference of the distal end of the toner supply container **30** in the back direction designated by arrow. The protuberance **32** is utilized when the toner supply container **30** is inserted into the rotary development unit **4**. A toner outlet port used for discharging fresh toner from the toner supply container **30** is formed in the circumferential surface of the toner supply container **30** in the vicinity of the proximate end face in the direction in which the toner supply container is inserted. As shown in the drawing, in a state in which the toner supply container **30** is not attached to the rotary development unit **4**, the toner outlet port is closed by means of a shutter **33** provided on the container. The shutter **33** is engaged with a pair of L-shaped rails **34**, **34** formed on the circumferential surface of the toner supply container **30**. The toner outlet port is opened by sliding the shutter **33** along the rails **34**. Further, a protruding wall (not shown) is formed around the toner outlet port, and the shutter **33** abuts against the protruding wall after having closed the toner outlet port.

FIG. **4** shows a panel member **60** having the container inlet port **61** for receiving the toner supply container **30** and the toner supply channel **50**. The panel member **60** has a fan-shaped form and includes a container retaining section **62** in which the container inlet port **61** is formed and a pipe **63** which protrudes from the reverse side of the container retaining section **62** and has the toner supply channel **50** formed therein. As shown in FIG. **5**, four panel members **60** corresponding to the respective developers are attached to the support frame **22**, thereby completing the front panel of the rotary development unit **4**.

The container retaining section **62** has a toner receiver chamber **64** for receiving the fresh toner discharged from the toner supply container **30**. The toner receiver chamber **64** is opened toward the container inlet port **61** via a toner inlet port **65**. As shown in FIG. **3**, in the state in which the toner supply container **30** is not attached to the container inlet port **61**, the toner inlet port **65** is closed by means of a shutter **66** provided on the receiver chamber **64**. The toner supply channel **50** formed in the pipe **63** is connected to the toner receiver chamber **64**. The fresh toner stored in the toner supply container **30** is conveyed to the toner supply channel **50** via the toner receiver chamber **64**. A toner outlet port **67** is formed in the vicinity of the front end of the pipe **63** protruding from the container retaining section **62**. The fresh toner conveyed from the toner receiver chamber **64** via the toner supply channel **50** is unloaded to the developer **40** via the toner outlet port **67**.

An indentation **68** is formed in the circumferential surface of the container inlet port **61** into which the toner supply container **30** is fitted. When the toner supply container **30** is fitted into the container inlet port **61**, the shutter **33** protruding from the circumferential surface of the toner supply container **30** is received by the indentation **68**. A pair of L-shaped rails **69** are formed on the side wall of the toner receiver chamber **64** adjoining the indentation **68**. The aforementioned shutter **66** engages the rails **69** in a slidable manner. Reference numeral **70** in FIG. **4** designates an indentation for receiving the protuberance **32** of the toner supply container **30**.

The toner supply container **30** is fitted into the container inlet port **61** of the panel member **60** in such a way that the shutter **33** is received by the indentation **68** of the container inlet port **61**. In this state, if the knob **31** of the toner supply container **30** is turned in a rightward direction, the toner supply container **30** itself rotates around its axis while the shutter **33** is received by the indentation **68**. The shutter **33** slides relatively to the toner supply container **30**, whereby a toner exit of the toner container **30** is opened. The thus-opened toner exit is moved until it is opposite to the toner inlet port **65** opened in the toner receiver chamber **64**. Concurrently, the protruding wall formed around the outlet port presses the shutter **66** provided on the receiver chamber **64**, so that the shutter **66** slides together with the toner supply container **30**, to thereby open the toner inlet port **65**. As a result, the toner exit port **33** of the toner supply container **30** is opposite to the toner inlet port **65** of the toner receiver chamber **64** while they are open (see FIG. **5**), thereby allowing the fresh toner stored in the toner supply container **30** to flow into the toner receiver chamber **64**.

FIG. **6** is a cross-sectional front view showing the developer **40** set in the development position. In the drawings, a helical coil agitator **35** is housed in the toner supply container **30**, and the fresh toner stored in the toner supply container **30** is conveyed to the toner exit port **33** by rotation of the coil agitator **35**. The thus-conveyed fresh toner is unloaded into the toner receiver chamber **64** through the toner exit port. A supply auger **51** is housed so as to pass through the toner receiver chamber **64** and the toner supply channel **50**. By rotation of the supply auger **51**, the fresh toner is conveyed to the toner outlet port **67** from the toner receiver chamber **64** through the inside of the toner supply channel **50** and is finally fed into the developer **40**. In the present embodiment, the supply auger **51** corresponds to the toner conveyor means according to the present invention.

The developing agent used for each developer **40** is a two-component developing agent comprising a mixture of non-magnetic toner and magnetic carriers. In each of the developers **40**, the developing agent is agitated in a mixing manner. An electrostatic latent image written on the photosensitive drum **1** is developed by means of a so-called magnetic brush developing method.

As shown in FIG. **6**, reference numeral **41** designates a housing incorporating the developing agent, and a developing-agent outlet port **42** is formed in the housing **41** so as to be opposite to the photosensitive drum **1**. A development roller **43** is disposed in the developing-agent outlet port **42** for producing a magnetic brush of the developing agent. The development roller **43** is formed from a cylindrical sleeve which covers a magnet roll polarized with a plurality of magnetic poles and rotates in the direction designated by arrow. The magnetic carriers are attached to the circumferential surface of the sleeve in the form of a chain by dint of the magnetic force of the magnet roll, to thereby form a magnetic brush of the developing agent. In association with the rotation of the sleeve, the magnetic brush is carried to the outside of the housing **41** from the developing-agent outlet port **42**, so that the tip of the magnetic brush comes into slidable contact with the photosensitive drum **1**. A trimmer blade **44** is fixed to the housing **41** while a given clearance is ensured between the development roller **43** and the trimmer blade **44**. The tip of the magnetic brush formed over the circumferential surface of the development roller **43** is trimmed to a certain length by means of the trimmer blade **44**.

A partition **45** is provided in the housing **42** in parallel with the axis of the development roller **43**. The inside of the housing **41** is divided into two developing agent chambers **46***a*, **46***b* by means of the partition **45**. A screw auger **47***a* is provided in the first developing agent chamber **46***a* so as to be adjacent to the development roll **43**. The screw auger **47***a*

rotates in the direction designated by arrow and conveys the developing agent stored in the first developing agent chamber **46***a* toward the front side of the developer **40** (i.e., the proximal end of the developer **40** in the direction at right angles to the drawing sheet of FIG. **6**). In contrast, a screw auger **47***b* is provided in the second developing chamber **46***b* adjacent to the first developing chamber **46***a* with the partition **45** between them. The screw auger **47***b* rotates in the direction designated by arrow and conveys the developing agent stored in the second developing agent chamber **46***b* toward the rear side of the developer **40** (i.e., the distal end of the developer **40** in the direction at right angles to the drawing sheet of FIG. **6**).

An opening for connecting the first developing agent chamber **46***a* to the second developing agent chamber **46***b* is formed on each longitudinal end of the partition **45**. The developing agent conveyed toward the front side in the first developing agent chamber **46***a* through rotation of the screw auger **47***a* is fed to the second developing agent chamber **46***b* by way of the opening formed in the vicinity of the front side of the developer **40**. In contrast, the developing agent conveyed toward the rear side in the second developing agent chamber **46***b* through rotation of the screw auger **47***b* is fed to the first developing agent chamber **46***a* by way of the opening formed in the vicinity of the rear side of the developer **40**. More specifically, in the developer **40**, the developing agents are circulated around the partition **45** in a certain direction through rotation of the pair of screw augers **47***a,* **47***b*. The developing agents are agitated through such circulation, and the frictional electrification of the toner is promoted.

The toner supply channel **50** is situated at an elevated position with reference to the second developing agent chamber **46***b* and is connected to the second developing agent chamber **46***b* through the toner outlet port **67**. The fresh toner conveyed from the toner supply container **30** through the toner supply channel **50** is unloaded into the front side of the second developing chamber **46***b*. Accordingly, the fresh toner supplied to the developer **40** cannot flow into the first developing agent chamber **46***a* without passing through the second developing agent chamber **46***b* from the front side toward the rear side of the developer **40**. The toner is agitated and mixed with the carriers during the course of transfer of the toner, thereby electrifying the toner. As a result, all the toner attached to the development roll **43** in the first developing agent chamber **46***a* is provided with a sufficient amount of electric charge. Reference numeral **48** designates a movable closure which is supported at one end by the housing **41** through use of a shaft. In a case where the developer **40** is turned upside down as a result of rotation of the rotary development unit **4**, the closure **48** covers the toner outlet port **67** to thereby prevent reverse flow of the developing agent to the toner supply channel **50** from the second developing agent chamber **46***b*.

In the developer **40**, according to the present embodiment, having the foregoing structure, as previously mentioned, the developing agent stored in the first developing agent chamber **46***a* is adsorbed by the development roll **43**, so that a magnetic brush is formed from the developing agent over the circumferential surface of the development roll **43**. The magnetic brush comes into slidable contact with the circumferential surface of the photosensitive drum **1** as the development roll **43** rotates. At this time, the toner is merely attached to the carriers forming the magnetic brush in an electrostatic manner and, therefore, is attracted toward the photosensitive drum **1** in accordance with the electric potential of an electrostatic latent image formed on the photosensitive drum **1**. The toner is liberated from the carriers and adheres to the photosensitive drum **1**. As a result, the electrostatic latent image is developed with toner. Further, since the carriers are retained by the development roll **43** by dint of the magnetic force, they do not adhere to the photosensitive drum **1**. The carriers are recovered into the housing **41** and are removed from the development roll **43**. The thus-removed carries are then returned to the first developing agent chamber **46***a*.

FIG. **7** shows a drive system of the developer **40**.

A rear frame **70** of the copier according to the embodiment is provided with drive gears **71** so as to correspond to the respective development positions of the developers **40**. These drive gears **71** are connected to a drive motor (not shown) via transmission clutches **72**. In contrast, the rotary shaft of the development roll **43** protrudes from the rear side of each developer **40**, and an input gear **73** is fixed to the tip end of the rotary shaft so as to mesh with the drive gear **71**. Accordingly, if the rotary development unit **4** rotates and brings the developer **40** in the development position opposite to the photosensitive drum **1**, the input gear **73** of the developer **40** meshes with the drive gear **71** of the rear frame **70**, thereby transmitting the torque of the drive motor to the development roll **43**. Further, the rotation of the development roll **43** is transmitted to each of the screw augers **47***a,* **47***b* of the developer **40** via gears **74** through **77**. If the development roll **43** commences rotating while the developer **40** is held in the development position, the screw augers **47***a,* **47***b* commence agitating the developing agent in conjunction with the rotation of the development roll **43**.

A gear **78** for driving the coil agitator **35** of the toner supply container **30** is provided on the rear side of the rotary development unit **4**. When the toner supply container **30** is fitted into the container inlet port **61** of the panel member **60**, the coil agitator **35** is connected to the gear **78** via a coupling **79**. Rotation is transmitted to the gear **78** from the development roll **43** via a plurality of gears (not shown), so that the development roll **43** and the coil agitator **35** are rotated in association with each other. During the course of rotation of the development roll **43** while the developer **40** is held in the development position, the coil agitator **35** sends the fresh toner stored in the toner supply container **30** to the toner exit port at all times. Accordingly, the toner receiver chamber **64** of the panel member **60** is always filled with fresh toner.

The supply auger **51** housed in the toner supply channel **50** is driven by means of a toner supply motor (not shown) differing from that is used for driving the development roll **43** and the coil agitator **35**. The toner supply motor is also disposed in such a way as to correspond to the development position and is configured so as to be connected to the supply auger **51** only when the developer **40** is held in the development position. In short, the fresh toner is supplied to the developer **40** only when the developer **40** is set in the development position. As previously mentioned, when the developer **40** is set in the development position, the toner receiver chamber **64** is always filled with fresh toner by means of operation of the coil agitator **35**. For this reason, the fresh toner is incessantly fed to the inside of the toner supply channel **50** as a result of rotation of the supply auger **51**. The quantity of fresh toner unloaded to the developer **40** from the toner supply channel **50** only depends on the number of rotations of the supply auger **51**. Therefore, in the copier according to the present embodiment, a drive signal used for driving the toner supply motor is generated in the manner as previously described, and the quantity of fresh toner to be supplied to the developer **40** is strictly controlled.

When the rotary development unit **4** is rotated in order to exchange the developer **40** with another one to be placed in the development position, the developer **40** and the toner supply container **30** revolve around the rotary shaft **21**. Even when the toner supply motor is suspended, the fresh toner filled in the toner supply channel **50** is conveyed through the toner supply channel **50** as if the toner supply channel **50** was rotating. As a result, depending on the direction in which the helical vane is wrapped around the shaft of the supply auger **51**, the fresh toner stored in the toner supply channel **50** is unintentionally supplied to the developer **40** during the course of rotation of the rotary development unit **4**. The development density of an electrostatic latent image cannot be controlled to a desired density.

To prevent such a problem, as shown in FIG. **2**, the developer **40** is exchanged by rotation of the support frame **22** in a clockwise direction, whilst fresh toner is supplied to the developer **40** by rotation of the supply auger **51** in a counterclockwise direction. With such a configuration, if the developer **40** is exchanged by rotation of the rotary development unit **4** while the supply auger **51** is suspended, the supply auger **51** is eventually rotated clockwise within the toner supply channel **50** during the course of exchange of the developer **40**. The fresh toner filled in the toner supply channel **50** is conveyed toward the toner receiver chamber **64** from the toner outlet port **67**, thereby preventing unintentional feeding of fresh toner to the developer **40**.

FIG. **8** is a block diagram showing a control system of the toner supply motor.

To control a mixture ratio of toner to carrier within the developer **40**, there is a need for ascertaining the quantity of toner consumed by the developer **40**, as well as for supplying the quantity of fresh toner corresponding to the quantity of consumed toner to the developer **40** from the toner supply channel **50**. To this end, in the copier according to the present embodiment, the quantity of toner required to develop an electrostatic latent image which is formed on the photosensitive drum **1** on the basis of the image data received from the original reader (not shown) is calculated from the image data for each developer **40**. On the basis of the result of such calculation, the quantity of fresh toner supplied to the developer **40** is determined.

More specifically, the image data converted into 8 bits of digital signal by means of an analog-to-digital converter (A/D converter) (not shown) are input to a quantity-of-image calculation section **81**. The quantity-of-image calculation section **81** calculates an output level of each of the pixels forming the image data and converts the thus-calculated output level to the number of video counts which serves as an indicator of toner consumption. The number of video counts is input to a quantity-of-toner-supply calculation section **82** consisting of a microcomputer, and the quantity-of-toner-supply calculation section **82** calculates, from the number of video counts, the time period during which a toner supply motor **80** is driven. When the developer **40** to be supplied is placed in the development position, the quantity-of-toner-supply **82** generates a drive signal for the toner supply motor **80**. The thus-generated drive signal is output to the toner supply motor **80**. As a result, the supply auger **51** is rotated, and only a given quantity of fresh toner is supplied to the developer **40** from the toner supply channel **50**.

Since there may arise a maximum of 200 msec lag until the toner supply motor **80** responds to the drive signal, the toner supply motor **80** is intermittently driven every 500 msec. The quantity-of-toner-supply calculation section **82** adds up the calculated time required to drive the toner supply motor **80** (hereinafter simply referred to as drive time) and generates a drive signal for the toner supply motor **80** every time the sum of the drive time exceeds 500 msec. After the generation of the drive signal, 500 msec is subtracted from the sum. As a result, the toner supply motor **80** is intermittently driven every time the sum of drive time output from the quantity-of-toner-supply calculation section **82** exceeds 500 msec, thereby ensuring feeding of fresh toner to the developer **40**.

Simple prediction of toner consumption of each developer **40** from the image data may result in a risk of failure to accurately feed the quantity of fresh toner corresponding to the toner consumption to the developer if actual toner consumption is different from the predicted toner consumption. For this reason, in the copier according to the present embodiment, a toner image of test pattern (hereinafter referred to as a reference patch) is formed on the photosensitive drum **1** once every several copies. The development density of the reference patch is detected, and the quantity of fresh toner to be supplied to each developer **40** is determined on the basis of the result of such detection.

More specifically, an electrostatic latent image having an image density of 50% is written on the photosensitive drum **1** through use of the laser beam scanner **3**. The thus-formed latent image is developed by the developer **40**, and the reference patch is formed. A photosensor **83** is disposed in the vicinity of the photosensitive drum**1** and reads the light reflected from the reference patch to thereby produce a detection signal corresponding to the intensity of the reflected light. The detection signal is input to a detected density calculation section **85** after having been amplified by means of an amplifier **84**, and the detected density calculation section **85** calculates the development density of the reference patch from the detection signal and outputs to the quantity-of-toner-supply calculation section **82** a density signal corresponding to the result of calculation. The quantity-of-toner-supply **82** compares the received density signal with the pre-stored density signal having an image density of 50%, to thereby determine whether or not the difference in density between the two signals is greater than a tolerance. If the difference is determined to be greater than the tolerance, the time period during which the toner supply motor **80** is suspended (hereinafter simply referred to as suspension time) is calculated from the difference in density. The suspension time is subtracted from the drive time of the toner supply motor **80** that is summed on the basis of the image data. In contrast, if the difference in density is determined to be smaller than the tolerance, additional time during which the toner supply motor **80** is driven (hereinafter simply referred to as additional drive time) is calculated from the difference in density. The thus-calculated additional drive time is added to the sum of the drive time of the toner supply motor **80**. As a result, toner deficiency in the developer **40** is ascertained on the basis of the actual development density of an electrostatic latent image, and the quantity of fresh toner to be supplied to the developer **40** can be increased or decreased corresponding to the quantity of toner deficiency. Consequently, the development density of the electrostatic latent image can be constantly maintained by controlling the quantity of fresh toner to be supplied to the developer **40**.

In order to prevent the fresh toner filled in the toner supply channel **50** from spilling in the developer **40** as a result of rotation of the rotary development unit **4**, as previously mentioned, the direction in which the supply auger **51** is rotated is set so as to be opposite to the direction in which

the rotary development unit **4** is rotated. When the rotary development unit **4** is rotated, the fresh toner is conveyed to the toner receiver chamber **64** through the inside of the toner supply channel **50**. However, if the fresh toner is reversely conveyed to the toner receiver chamber **64**, the fresh toner disappears from the vicinity of the toner outlet port **67** in the toner supply channel **50**. As a result, even if the toner supply motor **80** is rotated, no fresh toner is supplied to the developer **40** until the reversely-conveyed fresh toner arrives at the toner outlet port **67**, thereby making it impossible to supply to the developer **40** the quantity of fresh toner corresponding to the drive time of the toner supply motor **80**.

The shortage of the quantity of toner supply stemming from the conveyance of fresh toner through the toner supply channel **50** in the reverse direction corresponds to the number of rotations of the rotary development unit **4**. Therefore, in the present embodiment, there is counted the number of rotations achieved by the rotary development unit **4** until the developer **40** once returned from the development position is again placed in the development position. An increment for the drive time of the toner supply motor **80** is determined on the basis of the count value.

More specifically, the copier is provided with an illustrated number-of-rotation-of-unit count section **86** which counts the number of rotations achieved by the rotary development unit **4** after the developer **40** has been left from the development position until that development unit **4** is placed in the development position again. A count signal representing the count value is input to the quantity-of-toner-supply calculation section **82**, where an increment for the drive time of the toner supply motor **80** is calculated from the count signal. The thus-calculated increment is added to the sum of the drive time of the toner supply motor **80** calculated on the basis of the image data. In other words, the quantity-of-supply correction means according to the present invention is implemented by means of the quantity-of-toner-supply calculation section.

As a result, the drive time of the toner supply motor **80** can be increased by only the period of time corresponding to the time required for the fresh toner returned through the toner supply channel **50** to arrive at the toner outlet port **67** again. As a result, it becomes possible to prevent a shortage of fresh toner to be supplied to the developer **40** which would otherwise be caused by rotation of the rotary development unit **4**.

In consideration of the fact that the fresh toner is constantly unloaded from the toner supply container **30** into the toner receiver chamber **64** connected to the toner supply channel **50**, even if the rotary development unit **4** is rotated, the maximum distance over which the fresh toner is conveyed through the toner supply channel **50** in the reverse direction corresponds to merely the length of the toner supply channel **50**. Accordingly, if the number of rotations achieved by the rotary development unit **4** counted by the number-of-rotation-of-unit count section **86** are unlimitedly converted into an increment for the drive time of the toner supply motor **80**, a fear will be entertained as to an excess quantity of toner supplied to the developer **40**.

In the present embodiment, in order to eliminate such a fear, an upper limit value corresponding to the length of the toner supply channel **50** is set with respect to an increment for the drive time of the toner supply motor **80** calculated from the number of rotations of the rotary development unit **4**. If the an increment for the drive time of the toner supply motor **80** exceeds a preset upper limit value, the upper limit value is added to the drive time of the toner supply motor **80** calculated on the basis of the image data, thereby enabling accurate control of the quantity of fresh toner to be supplied to the developer **40**.

In the rotary development unit **4** according to the present embodiment, the supply auger **51** is connected to the toner supply motor **80** only at the development position. Consequently, the fresh toner filled in the toner supply channel **50** is prevented from being supplied to the developer **40** during the course of rotation of the rotary development unit **4**. The fresh toner is conveyed solely to the toner receiver chamber **64** through the toner supply channel **50**. Accordingly, the rotation of the rotary development unit **4** results in solely the conveyance of fresh toner in the reverse direction. For this reason, the number of all rotations achieved by the rotary development unit **4** is counted by the unit number-of-rotation count section **86**.

If the copier is also configured so as to supply fresh toner to the developer **40** during the course of rotation of the rotary development unit **4**, there is a need to count the number of rotations of the rotary development unit **4** when the fresh toner is not supplied to the developer **40**; i.e., the number of rotations achieved by the rotary development unit **4** only when the fresh toner is conveyed to the toner receiver chamber **64** through the toner supply channel **50**, by means of the unit number-of-rotation count section.

[Advantageous Results of the Invention]

As has been described above, in the rotary development unit according to the rotary development unit, even if a developer exchanger is rotated in order to exchange a developer to be placed in a development position, fresh toner can be prevented from being unintentionally supplied to the developer through a toner supply channel during the course of rotation of the developer exchanger, thereby preventing an excess quantity of toner from being stored in the developer. As a result, an electrostatic latent image formed over an image carrier can be developed at stable density.

If the number of rotations of the developer exchanger is counted by means of number-of-rotation count means, and the time period during which toner conveyor means is rotatively driven is corrected by means of quantity-of-supply correction means on the basis of the thus-obtained count value, there can be prevented a shortage of the quantity of fresh toner to be supplied to the developer which would otherwise be caused by rotation of the developer exchanger. As a result, the quantity of toner stored in the developer can be accurately controlled, thereby enabling development of an electrostatic latent image formed on an image carrier at stable density.

What is claimed is:

1. A rotary development unit comprising:

a plurality of developers for developing an electrostatic latent image formed on a latent image carrier with toner;

a developer exchanger which rotates while retaining the developers in a circumferential position around the developer exchanger and places at least one of the developers in a development position opposite to the latent image carrier;

a plurality of toner supply containers which store fresh toner to be supplied to the respective developers and are attached to the developer exchanger adjoining the respective developers;

toner supply channels which are provided substantially parallel with a rotary shaft of the developer exchanger

and communicate respectively between the developers and the toner supply containers; and

toner conveyor means for conveying a quantity of fresh toner corresponding to a given number of rotations of the toner conveyor means, from the toner supply containers to the respective developers through the respective toner supply channels,

wherein the fresh toner in the toner supply channels is conveyed back to the toner supply containers from the developers when the toner conveyor means is suspended and the developer exchanger is rotated.

2. A rotary development unit according to claim **1**, further comprising:

number-of-rotation count means for counting the number of rotations achieved by the developer exchanger until the developers left from the development position is reset to the development position again; and

quantity-of-supply correction means which determines, from the number of counts measured by the number-of-rotation count means, a corrected value for a time period over which the toner conveyor means is rotatively driven; and which increases the time period only by the corrected value.

3. A rotary development unit as defined in claim **2**, wherein the number-of-rotation count means counts the number of rotations achieved by the developer exchanger only when the toner conveyor means is suspended.

4. A rotary development unit as defined in claim **2**, wherein an upper limit corresponding to a length of the toner supply channels is set with regard to the corrected value of the time period over which the toner conveyor means is rotatively driven.

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